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| 09/388,989 | 09/02/1999 | BARNEY M. COHEN | AMAT/3191.03 | 4766 |

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| EXAMINER |
|---|
| PADGETT, MARIANNE L |

| ART UNIT | PAPER NUMBER |
|---|---|
| 1762 | |

DATE MAILED: 11/29/2002 20

Please find below and/or attached an Office communication concerning this application or proceeding.

PTO-90C (Rev. 07-01)

| Office Action Summary | Application No. 09/388,989 | Applicant(s) Cohen et al |
|---|---|---|
| | Examiner M.L. Padgett | Group Art Unit 1762 |

—The MAILING DATE of this communication appears on the cover sheet beneath th correspondence address—

**P riod for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, such period shall, by default, expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

☒ Responsive to communication(s) filed on 8/22/02 (IDS) + 8/26/02.

☒ This action is **FINAL.**

☐ Since this application is in condition for allowance except for formal matters, **prosecution as to the merits is closed** in accordance with the practice under *Ex parte Quayle,* 1935 C.D. 1 1; 453 O.G. 213.

**Disposition of Claims**

☒ Claim(s) 1, 3-4, 6, 8-14, 17-33 is/are pending in the application.

Of the above claim(s) ______ is/are withdrawn from consideration.

☐ Claim(s) ______ is/are allowed.

☒ Claim(s) 1, 3-4, 6, 8-14 + 17-33 is/are rejected.

☐ Claim(s) ______ is/are objected to.

☐ Claim(s) ______ are subject to restriction or election requirement

**Application Papers**

☐ The proposed drawing correction, filed on ______ is ☐ approved ☐ disapproved.

☐ The drawing(s) filed on ______ is/are objected to by the Examiner

☐ The specification is objected to by the Examiner.

☐ The oath or declaration is objected to by the Examiner.

**Pri rity under 35 U.S.C. § 119 (a)-(d)**

☐ Acknowledgement is made of a claim for foreign priority under 35 U.S.C. § 119 (a)-(d).

☐ All ☐ Some* ☐ None of the:

☐ Certified copies of the priority documents have been received.

☐ Certified copies of the priority documents have been received in Application No. ______.

☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a))

*Certified copies not received: ______.

**Attachment(s)**

☒ Information Disclosure Stat m nt(s), PTO-1449, Paper N (s). 18

☐ Notice of Reference(s) Cited, PTO-892

☐ Notice f Draftsperson's Pat nt Drawing R vi w, PTO-948

☐ Int rvi w Summary, PTO-413

☐ N tice of Informal Pat nt Application, PTO-152

☐ Oth r ______

**Office Action Summary**

1. This case is being reopened inorder to apply art supplied by applicant's IDS of 8/22/02. As applicant supplied the art after the final rejection, this action may be properly made final.

2. As noted in the advisory action, the 112 objections to claims 29 and 30, were corrected.

3. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

4. Claims 1, 3-4, 21 and 24-33 are rejected under 35 U.S.C. 103(a) as being unpatentable over Chang et al (5,043,299).

Chang et al teach cleaning processes for semiconductor wafers, which may have materials such as Al, $Al_2O_3$, Si, $SiO_2$, W, etc., on their surfaces, and subsequent deposition of tungsten on cleaned surfaces (abstract; figures; summary; col. 3, lines 13-26; col. 4, lines 45-53; Examples; and claims). (1) Particularly, a cleaning gas such as $NF_3$, $SF_6$, $BCl_3$ or $H_2$ may be mixed with a carrier gas, such as Ar or He, where the volume ratios used include 1:20 to 20:1 cleaning gas to carrier, hence may be predominately argon (col. 3, lines 13-35). Use of plasma with the cleaning gases (2) followed by a flushing step with carrier gas or $H_2$ is disclosed (Fig. 1-2; col. 3, lines 36-54 and col. 4, lines 23-44). While Chang et al teach this process generally for treatment of masked semiconductor surfaces, and example 1 uses a silicon dioxide mask, hence has a patterned dielectric on the substrate surface, there is no explicit teaching of the claimed combination of plasmas, with a patterned dielectric. However, it would have been obvious to one of ordinary skill in the art, that as masks that are dielectric are taught, and that

the flushing step is taught both with and without plasma, that the option of using plasma with the flushing step when the mask is $SiO_2$ or dielectric material would have been expected or suggested from Chang et al's teachings, because masks are commonly made of dielectric material (as in the example) and the use of plasma for the flushing is taught to assist in removing remaining residues, so is thus taught to be advantageous. While the aspect ratios of the masks are not discussed, cleaning both mask surfaces, and exposed surfaces of the substrate is the subject of Chang et al teaching, and one of ordinary skill in the art would have expected them to be used on typical aspect ratios for semiconductor manufacture, including those as claimed.

Chang et al does not explicitly teach the combination of $H_2$ + He in their flushing step which may be plasma, or in a subsequent $H_2$ cleaning step as in these claims 1 or 14, however He is taught as one of the carrier gases/non-oxidizing/inert gases that may be used, with $H_2$ taught for a reducing or non-oxidizing gas for flushing or after preceding cleaning steps. Column 4, lines 10-15, suggest use of combinations of gases exemplified by "helium, argon... or hydrogen or mixtures of the same" for preventing contamination after cleaning in passageway 70; and use of carrier or reducing ($H_2$) for flushing, hence it would have been obvious to one of ordinary skill in the art that a combination of He + $H_2$ would have been expected to be effectively employed after the flushing plasma, because each gas has been suggested separately therefore, and the gas use in the passageway is essentially a continuation of the flushing function employing like and claimed gases, so combinations suggested therefore would have been expected to have been equally effective in the flushing plasma option. Furthermore, as shown by Chang et al's claims 1 or 14 sequential plasma cleaning, a $H_2$-plasma may be used second after an initial plasma cleaning, and accordingly to col. 3, lines 13-25, all the cleaning gases which includes $H_2$ may be diluted with carrier gas that may be He, so even while

hydrogen may be used without dilution, the teachings suggest that it may be diluted, or that for $H_2$, the gas ratios for carrier to $H_2$ are 0:20 to 20:1 by volume. Note that applicants' claim of about 5% $H_2$ and about 95% He (by atomic %) gives 95:5 or 19:1, hence is within the bounds suggested by Chang et al's teachings, considering that the gases approach ideal gases for comparison of volume with atomic present.

It is further noted, that while applicants' claims as written, do not necessitate that the two plasma techniques be performed in any specific order, the use of "first" and "second" does imply that intent, but the label makes no actual requirement between these two steps in the claims (order of listing, does not necessitate any order of doing), therefore Chang et al's teaching of using the $H_2$ as a cleaning plasma, then performing a flushing plasma, where options of diluting the $H_2$ with He, and using Ar for flushing are chosen, would also read on the claims as presently written. For applicants claims read under this consideration, "the first plasma" may consist "essentially of Ar", because it is the flushing plasma. Therefore, so as long as the claims lack temporal requirements for the two plasmas, claim 3 is also read on by Chang et al.

5. Claims 1, 3-4, 6, 8-14, and 17-33 are rejected under 35 U.S.C. 103(a) as being unpatentable over Yoo et al, in view of Zhao et al.

After patterning a dielectric layer, Yoo et al teach two plasma etching steps (which can be considered to include cleaning), before metallizing, where a Ti/TiW (barrier) layer may be deposited before the Al. First an Ar plasma etch (1 or 2 minutes) with exemplified RF powers of 400W in a magnetic field of 50 Gauss, which smoothes sharp corners on the patterned dielectric layer. There may then follow a reactive ion etch of less than about 60 sec., where He plus a reactive gas, exemplified by $CF_4$ or $CF_3H$, then removes material at the bottom of the contact openings. Also, while Yoo et al teach generating plasma with an electric field, and prolonging it

with a magnetic field (col. 4, lines 60-63), they have no explicit discussion of the apparatus structure that produces these effects, nor is the "Applied Materials P5000 etch back chamber" used therefore in the example (col. 5) further described. However, the teaching of using an electric field, and the lack of any discussion on electrodes, would suggest to one of ordinary skill that external electrodes, antenna or coils were used to create the electric field, i.e., to create the plasma.

Yoo et at differs from the claims by not teaching $H_2$ as their active gas, and not giving all the parameters for their plasmas. While Yoo et al does not discuss aspect ratios *per se*, they do teach that the feature sizes etch in the integrated circuit structure are about 1µm or <u>less</u> (abstract) and teach various dielectric layer thickness from 1000 Å to 10,000 Å (col. 3, lines 63; col. 4, line 18), with the example making contact openings of 0.7 µm in dielectric layer of 7500 Å + 1000 Å= 8500 Å. thus effectively teaching aspect ratios as claimed due to these dimensions.

Zhao et al teach an Ar plus $H_2$ plasma using ratios of $H_2$ to Ar flow rate that maybe 1:20 to 100:1 (col. 3, lines 23-39), RF powers of 20-400 W with 250 watts preferred for including the plasma (col. 3, lines 40-50) and D.C. bias on substrate (col. 3, lines 51-55+), that will clean, i.e. etch, the bottoms and side walls at the bottoms of high aspect ratio vias, hence it would have been obvious to one of ordinary skill in the art the $H_2$ was a reactive gas which is a reducing gas that could have been used equivalently in the process of Yoo et al, in their second plasma step, that uses He + reactive gas, because it was shown to produce <u>like</u> <u>or</u> <u>equivalent</u> <u>effects</u> in <u>analogous</u> <u>situations</u> and etching configurations (i.e. high aspect ratio plasma treatments). Note that Yoo et al's exemplary gases ($CF_4$ or $CF_3H$) are electronegative or reducing, hence are being used in chemically analogous fashions, thus supporting the stated motivation. Power parameters of Zhao et al would have been expected to be applicable to the second plasma of Yoo for these alternative gases, and while D.C. bias is discussed in Zhao et al, the examiner

takes notice that D.C. and R.F. voltages of like absolute valves may generally be applied equivalently for acceleration of ions. Applicant have claimed the watts used to produce the bias, which is not directly comparable to the number of volts, however it is noted that for the first plasma of Yoo et al, Ar+ is desired to be used for sputtered etching, which is generally known to be most efficiently preformed using bias. While unlike Zhao et al, who combines the sputter etch and active etch, Yoo et al do the "soft" reactive etching second, where the reactive gas as discussed in both references will react with what is at the bottom of the via, and remove redeposited material on sidewalls (Zhao), hence as this is descriptive of an isotropic type process, no bias would have been desirable than in the first, Ar plasma, since it is desirable to etch in more directions than down. Overall power input would obviously need to be maintained inorder to maintain the plasma.

6. Claims 6, 8-14, 17-20 and 22-23 are rejected under 35 U.S.C. 103(a) as being unpatentable over Chang et al (299) as applied to claims 1, 3-4, 21 and 24-33 above, and further in view of Subrahmanyan et al, and optionally Yoo et al.

Chang et al differs from these claims by use of RF applied between an electrode (cathode) and grounded chamber walls, instead of use of RF applied to a coil, and parameters associated therewith. Also, no teaching of the option of first coating with a barrier layer is discussed.

Subrahmanyan et al are teaching analogous processes with multiple plasma cleaning steps followed by deposition of barrier or liner layers on dielectric before metal deposition (abstract and page 7-11), where an inductively coupled plasma reactor (Fig. 2, pages 13-14), which uses a coil 125 shows equivalent production of cleaning plasmas that may employ inert gases with reactive gases and $H_2$ reducing gases, to like surfaces for equivalent cleaning effects. Therefore, it would have been obvious to one of ordinary skill in the art to employ

plasma reactors where the plasma is induced by electric fields from coils to effect the cleaning plasma, because they have been shown to create plasma that effectively treat surfaces and substrates such as treated by Chang et al (299), so that they would have been expected to be equivalently effective. Subrahmanyan et al further provides for alterative deposition of Ti or Ti/TiN or doped Si barrier layers as well as Al or Cu metals on the cleaned surfaces (page 4, 7 and 11-12), such that it would have been obvious to apply such layers as they are consistent with Chang et al (299)'s product, and provide the advantage of the barrier layers' prevention of diffusion from the dielectric, etc. to the semiconductor device. Yoo et al discussed above, provides additional discussion related to both these topics that further shows the desirability and effectiveness of the use of induced plasma and barrier layers in like processes.

7. Applicant's arguments filed August 2002 and discussed above have been fully considered but they are not persuasive.

Applicant's arguments with respect to claims 1, 3-4, 6, 8-14 and 17-33 have been considered but are moot in view of the new ground(s) of rejection.

8. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

9. Any inquiry concerning this communication from the examiner should be directed to M. L. Padgett whose telephone number is (703) 308-2336. The examiner can generally be reached on Monday-Friday from about 8 a.m. to 4:30 p.m.; fax #(703) 872-9311 (after final) or 305-6078 (unofficial).

M.L. Padgett/dh
November 27, 2002

11/26/2002

Marianne L Padgett

MARIANNE PADGETT
PRIMARY EXAMINER